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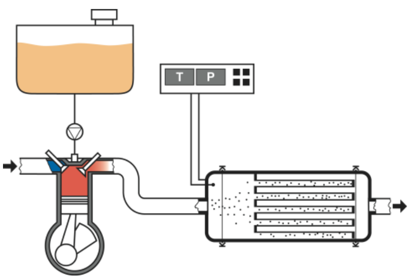
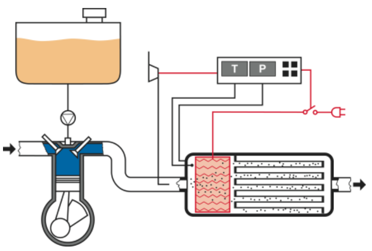
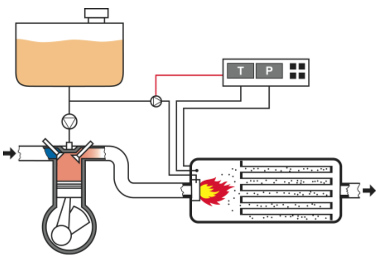
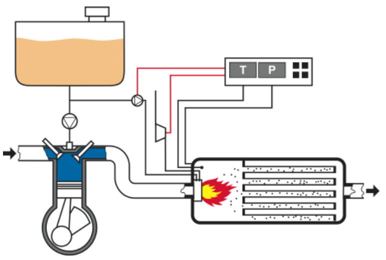
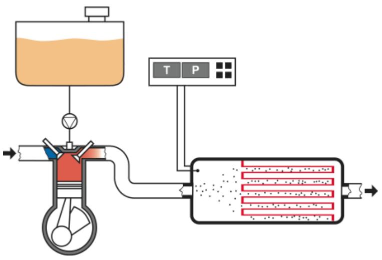
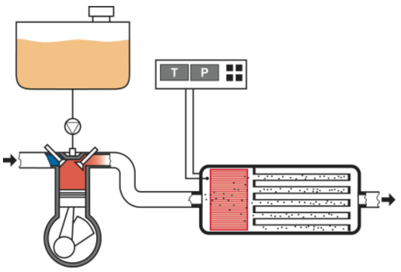
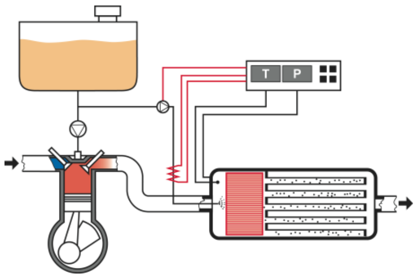
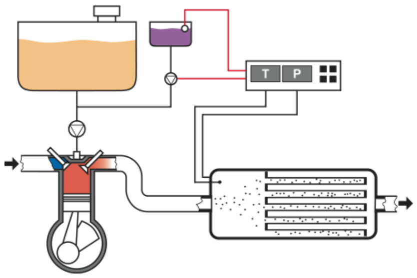
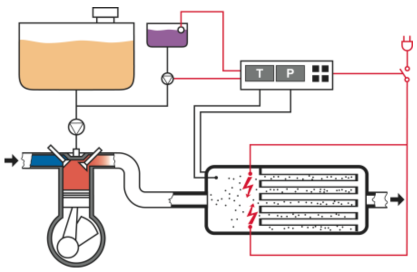
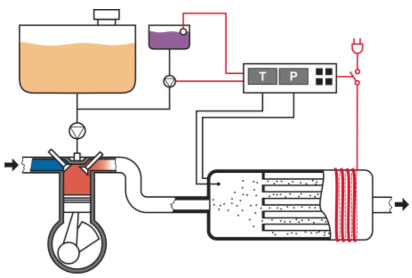
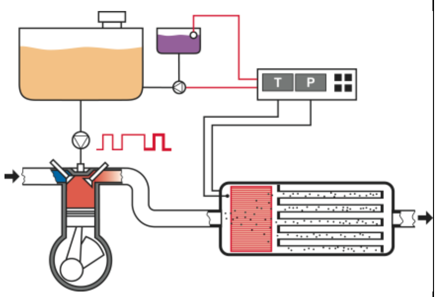
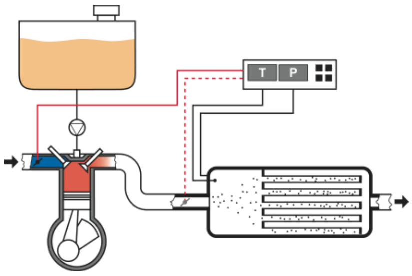
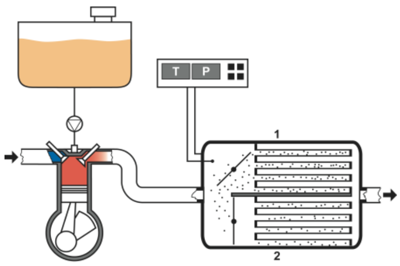
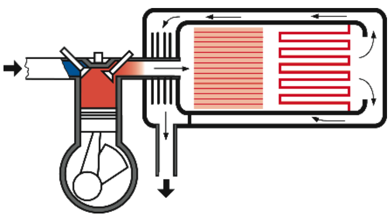
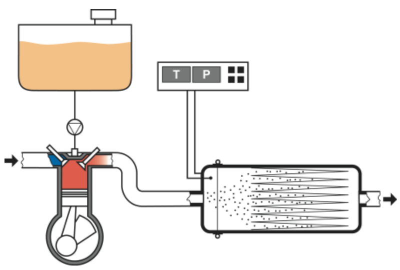
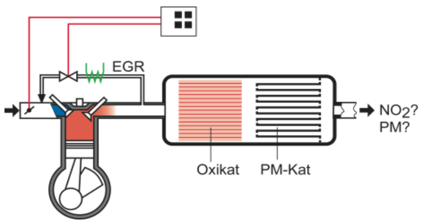
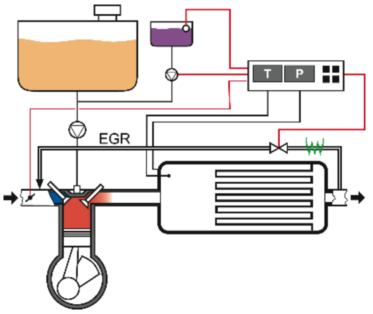
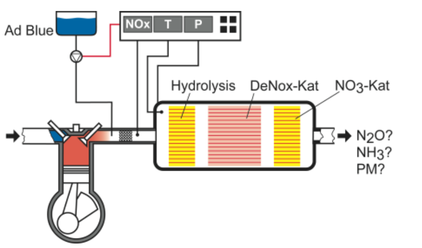
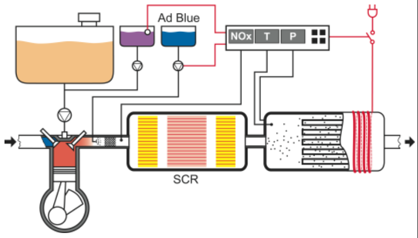
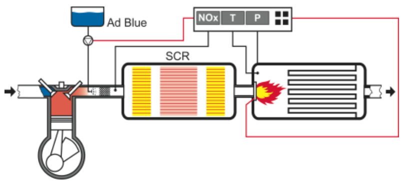
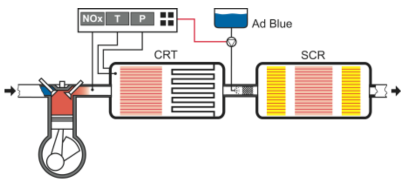
PARTICLE FILTER SYSTEMS: VARIABILITY OF SOLUTIONS

1		Filter Substrate exchanged for Regeneration offline Very often applied in mines and for forklifts, where regeneration conditions might be difficult. Filter substrate is not catalytically coated; can be easily exchanged via V-clambs and is regenerated offline by electricity or hot air. Clean substrate is installed immediately with very little downtime. A low-cost system with however needs regular maintenance.
2		Electric Regeneration onboard A classic system solution with slow and riskless over-night regeneration. Often applied in bus fleets, fleets of waste collectors, fire fighter vehicles or others where vehicles can be plugged-in over-night. No problem of secondary emission formation.
3		Full-flow Fuel Burner Guarantees regeneration under all operation conditions but requires a rather complex system control to sustain a clean burning flame under all engine load and speed conditions, stationary and also transient. Very successfully applied in locomotives and larger construction machines. No risk of secondary emissions.
4		Standstill Burner Very often used in small construction machines and forklifts where operation conditions are hardly predictable and long idling or low load operation might happen. An air compressor is required if the engine is at standstill during the regeneration process but air supplied by the engine might also be used at idle conditions. No risk of secondary emission formation.

5		Catalytic Coated Filter A coated catalyst can support the ordinary oxygen combustion of soot, accelerate the soot combustion process and lower the ignition temperature to below 350 °C. Mostly transition metals are used also in combination with rear-earth substances. Regeneration is fast and very efficient but a minimum temperature window is required one or two times per day. Certification must check for possible secondary emissions.
6		CRT-System: uncoated filter with upstream DOC Continuous Regeneration Trap – an ingenious invention by Johnson Matthey in 1988 could not be applied until fuel sulfur was reduced to values below 20 ppm. Now widely applied in road vehicles. Pt-coating converts NO to NO2, which splits again into NO and atomic O, which can burn soot at temperatures as low as 230 °C; a slow but elegant process; some NO2-slip is unavoidable.
7		Catalytic Fuel Burner Diesel-Fuel, finely distributed, maybe preheated or even a bit reformed to create more H_2 and CO and injected on at the surface of a standard DOC will start flameless combustion above 200 – 250 °C and can develop sufficient heat to burn the soot stored in the filter. A well controllable active regeneration system, combined with the CRT effect. Some NO2-slip is to be expected.
8		FBC = Fuel Borne Catalyst Transition metals are mixed to the fuel in metalorganic form (5-20 ppm) and transformed to catalytically active oxide clusters in the size of 3-10 nm. Attached to the soot particles they catalyse the combustion process at temperatures of 350°C. Combustion is fast and very efficient. Some FBC like Fe are sulfur tolerant to S>7000 ppm. FBC do not age. Concentration can easily be adjusted to the required level also automatically.
9		FBC with active Ignition Regeneration of a soot cake additized by FBC oxide clusters can be triggered by a local heat source. To conduct the heat to the depth of the filter in order to clean it completely the filter material should be heat conductive. Certain exhaust gas conditions like temperature and oxygen content are required to avoid interruption of the regeneration process.
10		FBC with active Ignition = SMF®-AR A system which is widely used for construction machines or other applications which have particularly demanding and unpredictable operating conditions. The sinter metal substrate provides the heat conductivity and the local ignition at the downstream part of the filter leads to a flame propagation towards the intake. A very fast, well controllable and efficient regeneration method.

11		FBC + CRT: the PSA system 5/2000 with temperature management by retarded injection Some application require either active filter systems or management of the exhaust temperature such that a passive system reaches his operation window. In 2000 PSA used the electronic control of the injection timing to retard injection whenever regeneration was required. Exhaust temperature reached a level to trigger flameless post combustion on the DOC in order to generate enough temperature for FBC regeneration.
12		Temperature Management by Throttling Throttling of intake air or exhaust gas is another very efficient measure to rise exhaust temperatures to near full-load levels. To avoid increase of fuel consumption due to back pressure losses the throttling phase must remain short. Combination with FBC to trigger a self-sustained combustion process is recommended.
13		Temperature Management by Heat Storage Use phases of high exhaust gas temperatures to warm up and regenerate one filter element while passing cold gas to the neighbor element is another technical system to cope with changing operation conditions. Twin filter systems, also with active burners, were widely used in the beginning but seem to disappear because of their higher complexity.
14		Temperature Management by Heat Recuperation Small temperature increments due to catalytic conversion or filter regeneration can be recuperated to increase the temperature, stabilize and accelerate the process. Fast regenerations are possible. The process is fully passive but self-regulating. Healt losses and heat transfer determine the overall efficiency.
15		Disposable Filter Filter materials based on organic fibers are available which can tolerate temperatures as high as 300°C, glass fibers permit over 600 °C. Industry offers low cost cartridges with pleated paper structures which permit the design of soot filters collecting and storing soot during several hundred hours. After reaching the permissible backpressure they are disposed as industrial waste. Efficiencies can easily reach VERT®-limits of > 97 %.

16.		High-Pressure EGR and Filtration Unregulated EGR as it is still used for some older generation Diesel engines will be influenced by varying backpressure of a filter system and even more by throttling. In this case backpressure should remain below 120 mbar while in all other cases 200 mbar are admissible. The better solution is of course the close-loop control of the EGR-valve and interrupt EGR during throttle intervention.
17.		FBC-Filter with Low-Pressure EGR Recirculate exhaust gas from downstream filter – also called "clean gas induction" is recommended instead. Contamination of the EGR system, the cooler and the engine can be avoided and even higher EGR-rates are permitted. Regulation however might be more difficult
18.		SCR classic without Filtration NOx reduction by selective catalytic reaction using ammonia or urea as reductant substances also requires a minimum exhaust temperature of > 230 °C and creates backpressure the flow resistance of the catalyst and the mixers. It also requires about as much space as a particle filters. The challenge is therefore to use either SCR or DPF or to solve the difficult problem to combine both.
19.		SCR upstream active FBC-Filter DPF downstream of SCR might suffer from lower exhaust temperatures. An active filter system like SMF®-AR can solve this problem. This solution is in place in trucks and buses

20.		SCR upstream Full Flow Burner Filter Another active solution with a full flow burner, a standstill burner or an idle burner might also solve this problem These 2 solutions are recommended in all cases where vehicles homologated with SCR shall be retrofitted.
21.		SCR downstream CRT-Filter If the vehicle has no SCR yet but shall be equipped with a deNOx-System and an efficient filter the arrangement can be freely selected. Recent development however has demonstrated that an even better solution will be to coat the SCR on the filter surface itself – the so-called SDPF, which can bring the space requirement again back to the size of the silencer to be replaced.

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